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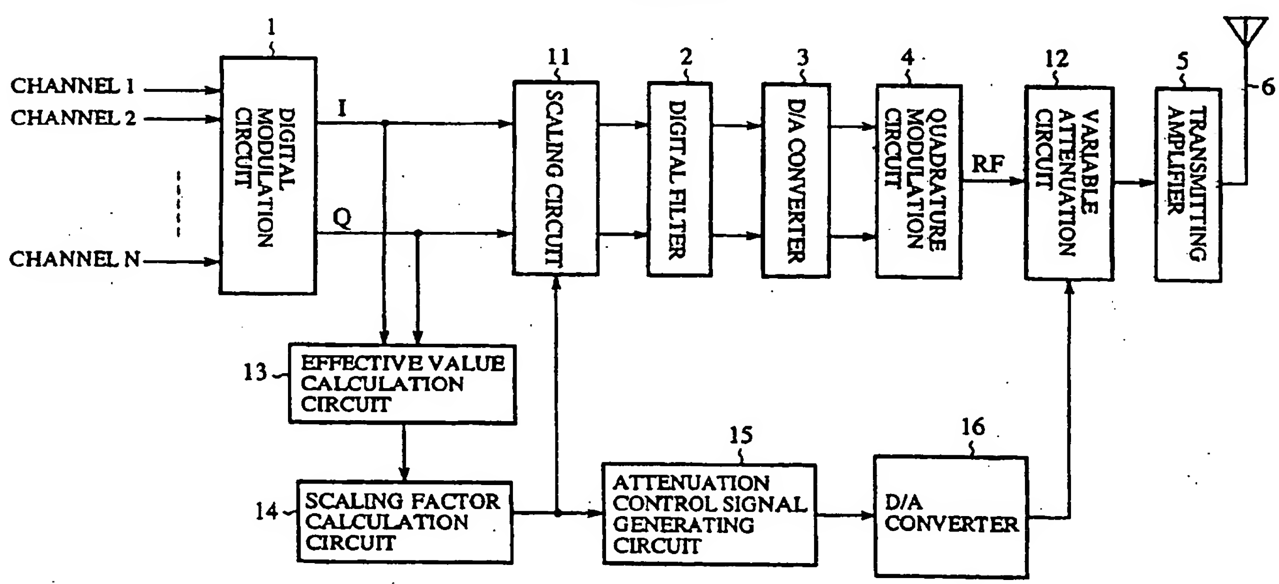
(54) MULTIPLEX COMMUNICATION SYSTEM AND METHOD OF SIGNAL PROCESSING

(57) A multiplex communication system includes a scaling circuit for controlling, in response to a scaling control signal, the signal level of a digital multiplex signal digital generated by a modulation circuit; a variable attenuation circuit for attenuating the signal level of the RF signal output from a quadrature modulation circuit in response to an attenuation control signal; and a control signal generating circuit for generating a scaling control signal in response to the effective value of the digital multiplex signal generated by the digital modulation circuit and in accordance with a digital conversion value corresponding to a desired input level of the quadrature modulation circuit, for supplying its output to the scaling circuit, for generating an attenuation control signal in response to the scaling control signal, and for supplying it to the variable attenuation circuit.

FIG.2



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Description

TECHNICAL FIELD

[0001] The present invention relates to a multiplex communication system and its signal processing method.

BACKGROUND ART

[0002] As communication schemes of a multiplex communication system that carries out communications by multiplexing digital signals of multiple channels, there are FDMA (Frequency Division Multiplex Access), TDMA (Time Division Multiplex Access), CDMA (Code Division Multiplex Access) and the like. Fig. 1 is a block diagram showing a configuration of a conventional direct sequence CDMA base station transmitter. In this figure, the reference numeral 1 designates a digital modulation circuit that carries out data modulation and direct sequence CDMA modulation of coded transmission data of multiple channels to generate spread modulation signals each with an in-phase I component and a quadrature Q component, and that carries out multiplex processing of the I components and Q components of the channels independently, thereby generating a digital multiplex signal with an I component and a Q component. The reference numeral 2 designates a digital filter for band-limiting the I and Q components of the digital multiplex signal independently; and 3 designates a D/A converter for converting the I and Q components into analog signals, respectively, thereby generating analog baseband signals of the I and Q components. The reference numeral 4 designates a quadrature modulation circuit for converting the analog baseband signals of the I and Q components into an RF signal; 5 designates a transmitting amplifier for amplifying the RF signal; and 6 designates a transmitting antenna.

[0003] Next, the operation will be described.

[0004] The digital modulation circuit 1 separates the coded transmission data of each channel to the I and Q components through the data modulation, followed by the direct sequence CDMA modulation. In addition, the I and Q spread signals of individual channels are summed up separately for the I and Q components by a multiplexing circuit installed in the digital modulation circuit 1, and are output as the I and Q components of the digital multiplex signal. In the direct sequence CDMA scheme, the transmission power of each channel is variable independently. Accordingly, the digital multiplex signal consisting of the I and Q components generated by the digital modulation circuit 1 is multivalued data with amplitude fluctuations.

[0005] The digital filter 2 band-limits the digital multiplex signal consisting of the I and Q components, which is the multivalued data. The D/A converter 3 converts the I and Q components into the analog signals, respectively, thereby generating the analog baseband signals consisting of the I and Q components. The quadrature modulation circuit 4 up-converts the analog baseband signals consisting of the I and Q components to the RF signal. The transmitting amplifier 5 amplifies the RF signal, and transmits the amplified RF signal via the transmitting antenna 6.

[0006] In the conventional direct sequence CDMA base station transmitter, the signal level of the analog baseband signal supplied to the quadrature modulation circuit 4 fluctuates because of the multiplexing state of the base station or becasuse of the fluctuations of each channel power. When the signal level of the analog baseband signal supplied to the quadrature modulation circuit 4 exceeds the dynamic range that will achieve good characteristics of the quadrature modulation circuit 4, a drawback can arise because of the degradation in frequency characteristics due to adjacent channel leakage power.

[0007] Accordingly, to maintain good quality of the transmission waveform and frequency characteristics even at the maximum power transmission, the quadrature modulation circuit 4 is adjusted such that the signal level of the input analog baseband signal takes a maximum value within the dynamic range that will enable the good characteristics.

[0008] In the conventional direct sequence CDMA base station transmitter with the foregoing configuration, the signal level of the analog baseband signal, that is, the dynamic range of the digital multiplex signal generated by the digital modulation circuit 1 becomes the dynamic range required of the quadrature modulation circuit 4. However, since the digital modulation circuit 1 multiplexes multiple channels, the number and power of which vary greatly, the signal level of the digital multiplex signal fluctuates greatly. As a result, the dynamic range of the analog baseband signal becomes much greater than the dynamic range of the quadrature modulation circuit 4.

[0009] On the other hand, when the total power of the variable powers multiplexed by the digital modulation circuit 1 is small, or the number of the multiplexing is small, the signal level of the digital multiplex signal is small. Thus, the analog baseband signal is much smaller than the dynamic range of the quadrature modulation circuit 4. As a result, a carrier leakage component becomes dominant over the RF signal generated by the quadrature modulation circuit 4, thereby causing a problem of the degradation in the waveform quality.

[0010] The present invention is implemented to solve the foregoing problem. Therefore, an object of the present invention is to provide a multiplex communication system and its signal processing method that can limit the degradation in the transmission signal waveform quality because of too great or too small an input signal level to the quadrature modulation circuit, and that can correct the signal level in the stages following the quadrature modulation circuit to its normal level. It is achieved by maintaining the input signal level to the

quadrature modulation circuit within the dynamic range of the quadrature modulation circuit, even when the signal level of the digital multiplex signal fluctuates because of the multiplexing state of the base station or because of the power fluctuations of individual channels.

DISCLOSURE OF THE INVENTION

[0011] According to a first aspect of the present invention, there is provided a multiplex communication system in which signal converting means converts into an analog baseband signal a digital multiplex signal consisting of a plurality of digital signals multiplexed, and in which quadrature modulation means converts the analog baseband signal into an RF signal, the multiplex communication system comprising:
scaling calculation means for calculating a scaling factor, which is used for amplitude adjusting processing of the digital multiplex signal, in response to an amplitude of the digital multiplex signal generated by digital modulation means and in accordance with an amplitude range suitable for signal processing by the quadrature modulation means;
scaling control means for performing the amplitude adjusting processing of the digital multiplex signal in response to the scaling factor calculated by the scaling calculation means, and for supplying its result to the signal converting means; control signal generating means for generating a correction control signal in response to the scaling factor generated by the scaling calculation means; and signal correcting means for performing, in response to the correction control signal, correction processing of the RF signal output from the quadrature modulation means to cancel out effect of the amplitude adjusting processing carried out by the scaling control means.

[0012] Thus, it can prevent the degradation in frequency characteristics because of adjacent channel leakage power that can occur when the input signal level to the quadrature modulation means is too large, and the degradation in waveform quality because of the dominant carrier leakage component of the RF signal that can occur when the input signal level is too small. In addition, it can cancel out the effect of the control by the scaling control means on the RF signal output from the quadrature modulation means, thereby offering an advantage of being able to correct the signal level to its original level.

[0013] Here, in the multiplex communication system, the control signal generating means may calculate the scaling factor from an effective value of amplitudes of an in-phase component and a quadrature component of the digital multiplex signal and from a digital conversion value of the amplitude range suitable for the signal processing of the quadrature modulation means, the digital multiplex signal being generated by data modulation followed by direct sequence CDMA modulation of coded transmission data of multiple channels by the digital modulation means.

[0014] Thus, in the multiplex communication of the direct sequence CDMA scheme, it can prevent the degradation in frequency characteristics because of adjacent channel leakage power that can occur when the input signal level to the quadrature modulation means is too large, and the degradation in waveform quality because of the dominant carrier leakage component of the RF signal that can occur when the input signal level is too small. In addition, it can cancel out the effect of the control by the scaling control means on the RF signal output from the quadrature modulation means, thereby offering an advantage of being able to correct the signal level to its original level.

[0015] In the multiplex communication system, the control signal generating means may calculate the scaling factor by $S = INT\{\log_2(D/Z)\}$, and supply the scaling factor to the scaling control means as a scaling control signal, and the scaling control means may shift up by S bits the digital multiplex signal consisting of the in-phase component and quadrature component generated by the digital modulation means when the scaling control signal is positive, and shift it down by S bits when the scaling control signal is negative.

[0016] Thus, it offers an advantage of being able to achieve the scaling processing easily by the bit shift processing by the scaling means.

[0017] In the multiplex communication system, the control signal generating means may provide the digital conversion value D with a hysteresis characteristic, and carry out S-bit shift up or down of the digital multiplex signal composed of the in-phase component and quadrature component generated by the digital modulation means.

[0018] Thus, even when the effective value of the digital multiplex signal repeats the increase and decrease near the changing point of the scaling factor, it can prevent the scaling factor from being changed frequently. As a result, it is not necessary for the scaling control means to carry out the bit shift processing frequently, and for the control signal generating means to generate the attenuation control signal frequently, thereby making it possible to improve the stability of the operation.

[0019] In the multiplex communication system, the control signal generating means may supply the signal correcting means with the correction control signal passing through RAMP processing that is performed in response to the correction control signal generated at a predetermined time before and the correction control signal generated at present.

[0020] Thus, it can smooth the variations in the correction control signal to be supplied, thereby offering an advantage of being able to prevent the degradation in the frequency characteristics because of the abrupt change in the correction control signal.

[0021] According to a second aspect of the present invention, there is provided a signal processing method of a multiplex communication system in which signal

signal generated by digital modulation means and in accordance with an amplitude range suitable for signal processing by said quadrature modulation means;
scaling control means for performing the amplitude adjusting processing of the digital multiplex signal in response to the scaling factor calculated by said scaling calculation means, and for supplying its result to said signal converting means;
control signal generating means for generating a correction control signal in response to the scaling factor generated by said scaling calculation means; and
signal correcting means for performing, in response to the correction control signal, correction processing of the RF signal output from said quadrature modulation means to cancel out effect of the amplitude adjusting processing carried out by said scaling control means.

2. The multiplex communication system according to claim 1, wherein said control signal generating means calculates the scaling factor from an effective value of amplitudes of an in-phase component and a quadrature component of the digital multiplex signal and from a digital conversion value of the amplitude range suitable for the signal processing of said quadrature modulation means, the digital multiplex signal being generated by data modulation followed by direct sequence CDMA modulation of coded transmission data of multiple channels by said digital modulation means.

3. The multiplex communication system according to claim 2, wherein said control signal generating means calculates the scaling factor by

$$S = \mathrm{INT}\{\log_2(D/Z)\}$$

where

S is the scaling factor,
INT is a function for taking an integer value,
Z is the effective value of the digital multiplex signal, and
D is the digital conversion value,

and supplies the scaling factor to said scaling control means as a scaling control signal, and wherein said scaling control means shifts up by S bits the digital multiplex signal consisting of the in-phase component and quadrature component generated by said digital modulation means wh n the scaling control signal is positive, and shifts down by S bits the digital multiplex signal consisting of the in-phase component and quadrature component generated by said digital modulation means when the scaling control signal is negative.

4. The multiplex communication system according to claim 3, wherein said control signal generating means provides the digital conversion value D with a hysteresis characteristic, and carries out S-bit shift up or down of the digital multiplex signal composed of the in-phase component and quadrature component generated by said digital modulation means.

5. The multiplex communication system according to claim 1, wherein said control signal generating means supplies said signal correcting means with the correction control signal passing through RAMP processing that is performed in response to the correction control signal generated at a predetermined time before and the correction control signal generated at present.

6. The multiplex communication system according to claim 2, wherein said control signal generating means supplies said signal correcting means with the correction control signal passing through RAMP processing that is performed in response to the correction control signal generated at a predetermined time before and the correction control signal generated at present.

7. The multiplex communication system according to claim 3, wherein said control signal generating means supplies said signal correcting means with the correction control signal passing through RAMP processing that is performed in response to the correction control signal generated at a predetermined time before and the correction control signal generated at present.

8. The multiplex communication system according to claim 4, wherein said control signal generating means supplies said signal correcting means with the correction control signal passing through RAMP processing that is performed in response to the correction control signal generated at a predetermined time before and the correction control signal generated at present.

9. A signal processing method of a multiplex communication system in which signal converting means converts into an analog baseband signal a digital multiplex signal consisting of a plurality of digital signals multiplexed, and in which quadrature modulation means converts the analog baseband signal into an RF signal, said signal processing method comprising the steps of:

calculating a scaling factor, which is used for

amplitude adjusting processing of the digital multiplex signal, in response to an amplitude of the digital multiplex signal generated by digital modulation means and in accordance with an amplitude range suitable for signal processing by said quadrature modulation means;
performing the amplitude adjusting processing of the digital multiplex signal in response to the scaling factor calculated, and for supplying its result to said signal converting means;
generating a correction control signal in response to the scaling factor generated; and
performing, in response to the correction control signal, correction processing of the RF signal output from said quadrature modulation means to cancel out effect of the amplitude adjusting processing.

FIG.1

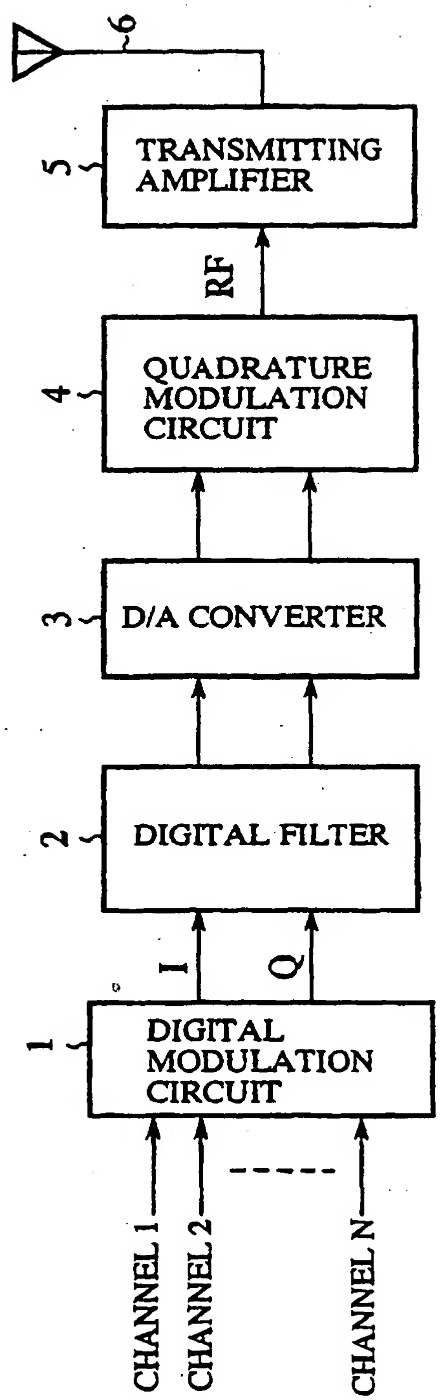

CHANNEL 1
CHANNEL 2
CHANNEL N
DIGITAL MODULATION CIRCUIT
1
I
Q
DIGITAL FILTER
2
D/A CONVERTER
3
QUADRATURE MODULATION CIRCUIT
4
RF
TRANSMITTING AMPLIFIER
5
6

FIG.2

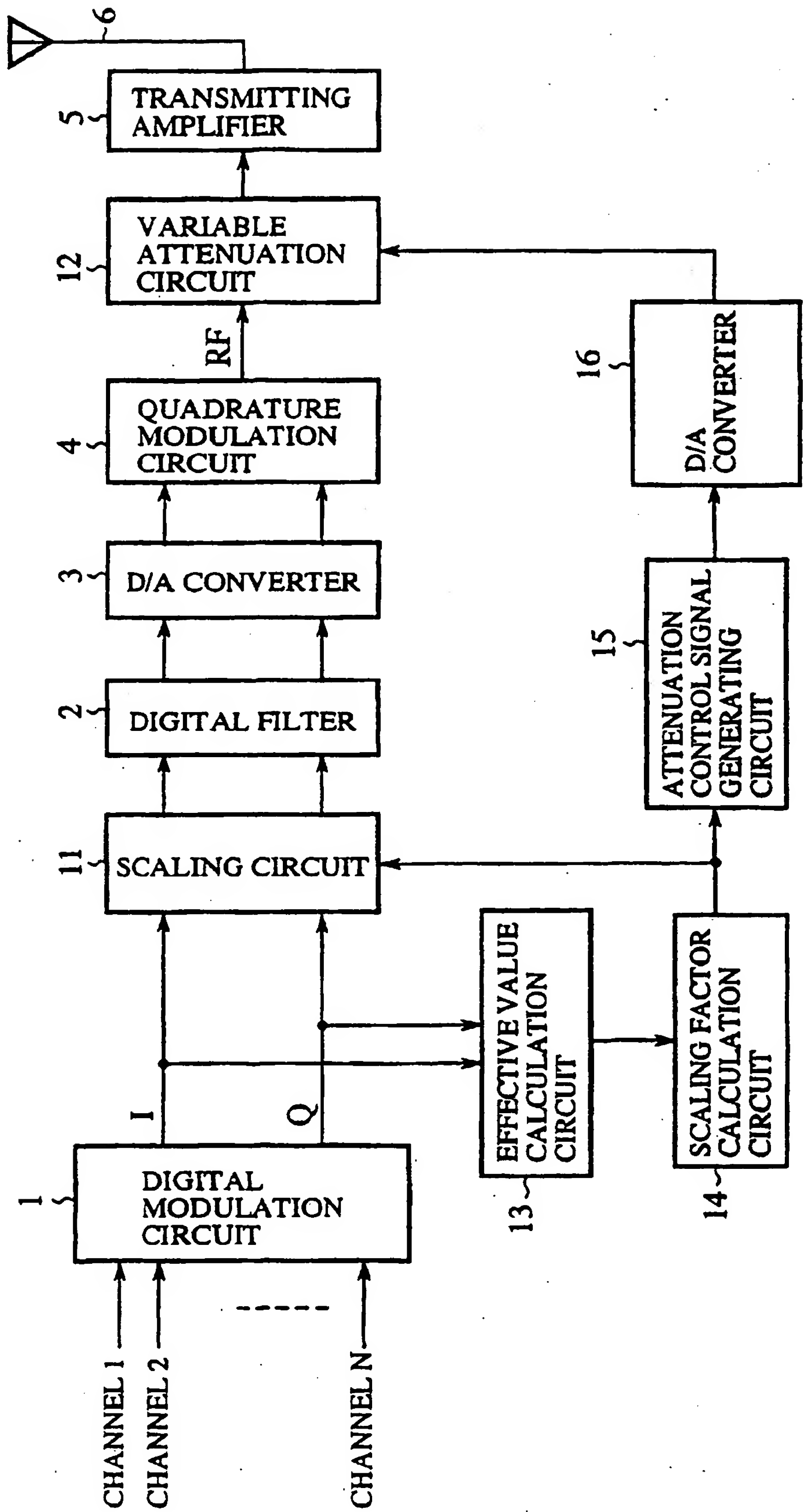

TRANSMITTING AMPLIFIER
VARIABLE ATTENUATION CIRCUIT
RF
QUADRATURE MODULATION CIRCUIT
D/A CONVERTER
DIGITAL FILTER
SCALING CIRCUIT
I
Q
DIGITAL MODULATION CIRCUIT
CHANNEL 1
CHANNEL 2
CHANNEL N
EFFECTIVE VALUE CALCULATION CIRCUIT
SCALING FACTOR CALCULATION CIRCUIT
ATTENUATION CONTROL SIGNAL GENERATING CIRCUIT
D/A CONVERTER
1
2
3
4
5
6
11
12
13
14
15
16

FIG.3

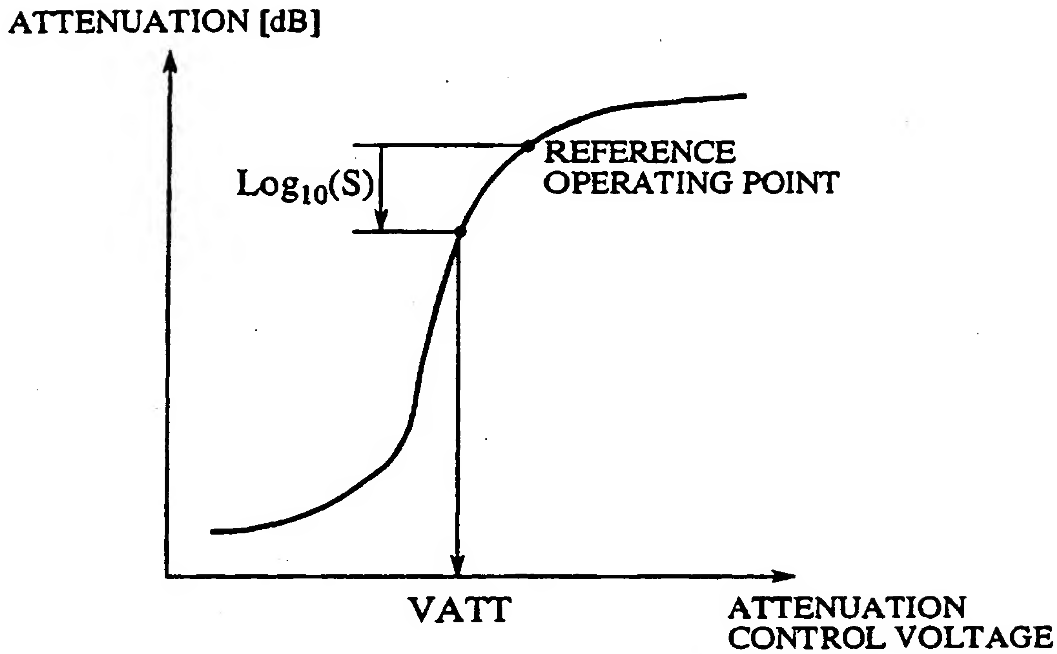

ATTENUATION [dB]
$Log_{10}(S)$
REFERENCE
OPERATING POINT
VATT
ATTENUATION
CONTROL VOLTAGE

FIG.4

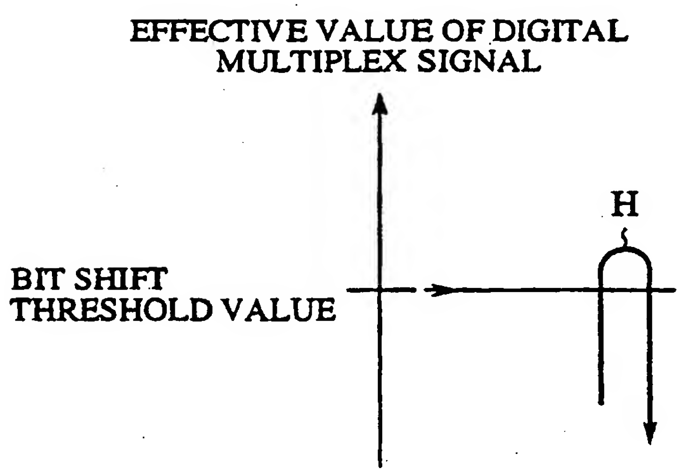

EFFECTIVE VALUE OF DIGITAL
MULTIPLEX SIGNAL
H
BIT SHIFT
THRESHOLD VALUE

FIG.5

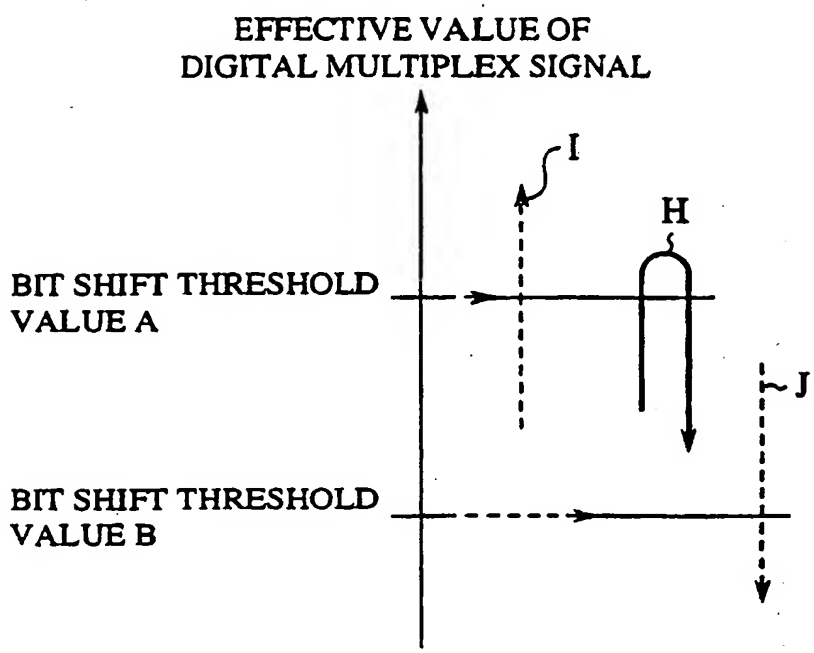

EFFECTIVE VALUE OF
DIGITAL MULTIPLEX SIGNAL
I
H
BIT SHIFT THRESHOLD
VALUE A
J
BIT SHIFT THRESHOLD
VALUE B

FIG.7

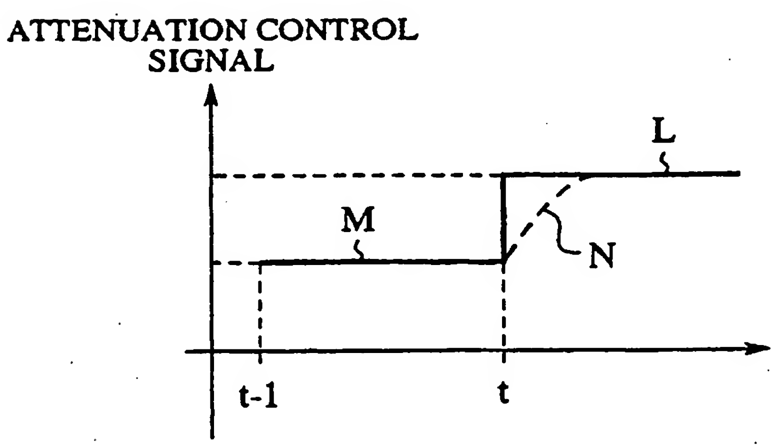
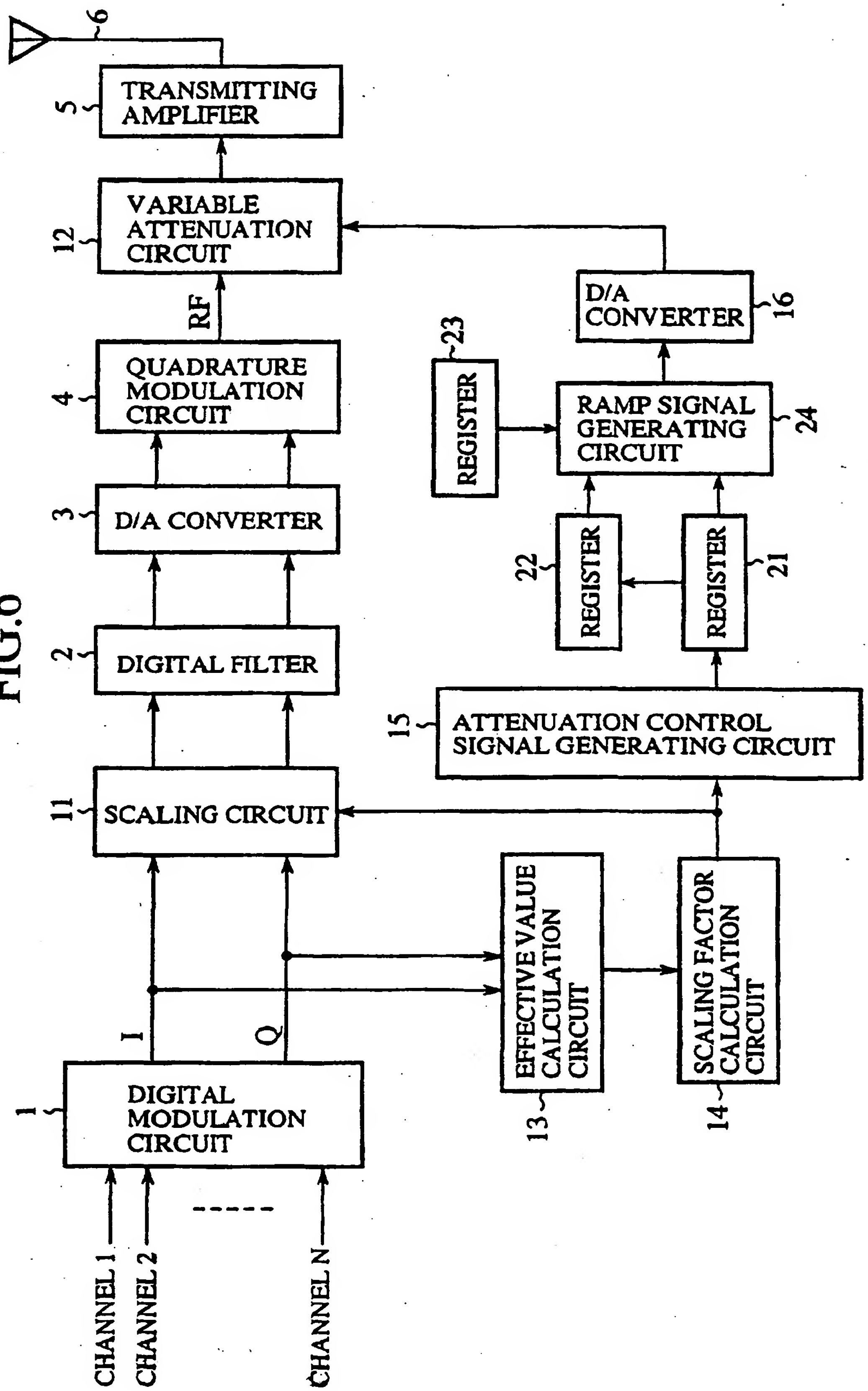

ATTENUATION CONTROL
SIGNAL
L
M
N
t-1
t

FIG.6


6
TRANSMITTING AMPLIFIER
5
VARIABLE ATTENUATION CIRCUIT
12
RF
QUADRATURE MODULATION CIRCUIT
4
D/A CONVERTER
3
DIGITAL FILTER
2
SCALING CIRCUIT
11
I
Q
DIGITAL MODULATION CIRCUIT
1
CHANNEL 1
CHANNEL 2
CHANNEL N
D/A CONVERTER
16
REGISTER
23
RAMP SIGNAL GENERATING CIRCUIT
24
REGISTER
22
REGISTER
21
ATTENUATION CONTROL SIGNAL GENERATING CIRCUIT
15
EFFECTIVE VALUE CALCULATION CIRCUIT
13
SCALING FACTOR CALCULATION CIRCUIT
14

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP01/02953

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl^{7} H04J13/04, H04B1/707

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl^{7} H04B1/69-1/713, H04J13/00-13/06, H04L27/00-27/38

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1926-1996	Toroku Jitsuyo Shinan Koho	1994-2001
Kokai Jitsuyo Shinan Koho	1971-2001	Jitsuyo Shinan Toroku Koho	1996-2001

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
JOIS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP, 10-308718, A (NEC Saitama Ltd.), 17 November, 1998 (17.11.98), page 2, column 2, lines 37 to 42; page 3, column 3, line 50 to page 5, column 8, line 13; all drawings (Family: none)	1,2,9 3-8
A	JP, 8-79132, A (Matsushita Communication Industrial Co., Ltd.), 22 March, 1999 (22.03.99), Full text; all drawings (Family: none)	1-9
A	JP, 10-65647, A (NTT Ido Tsushinmo K.K.), 06 March, 1998 (06.03.98), Full text; all drawings (Family: none)	1-9
A	JP, 10-178414, A (Fujitsu Limited), 30 June, 1998 (30.06.98), Full text; all drawings & KR, 98063366, A & KR, 232554, B1 & US, 6009090, A	1-9

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search 26 June, 2001 (26.06.01)	Date of mailing of the international search report 10 July, 2001 (10.07.01)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No. PCT/JP01/02953

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 10-126309, A (Hitachi, Ltd.), 15 May, 1998 (15.05.98), Full text; all drawings & KR, 98032777, A & US, 6144694, A	1-9
A	JP, 11-234229, A (NEC Saitama Ltd.), 27 August, 1999 (27.08.99), Full text; all drawings (Family: none)	1-9
P,X P,A	JP, 2000-138655, A (Kokusai Electric Co., Ltd.), 16 May, 2000 (16.05.00), page 6, column 9, line 45 to page 7, column 12, line 39; Figs. 3, 5, 9 (Family: none)	1,2,9 3-8
P,X P,A	JP, 2000-244449, A (Kokusai Electric Co., Ltd.), 08 September, 2000 (08.09.00), page 4, column 5, line 28 to page 6, column 9, line 21; Figs. 4 to 6 (Family: none)	1,2,9 3-8
P,A	JP, 2000-183851, A (NEC Corporation), 30 June, 2000 (30.06.00), Figs. 2 to 4 & EP, 1011207, A2 & AU, 9965252, A & CN, 1258144, A & KR, 2000057065, A	3
P,A	JP, 2001-44857, A (NEC Corporation), 16 February, 2001 (16.02.01), Full text; Fig. 4 (Family: none)	4

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